**Genetics Problems**

**Key terms:**

* Percentage
* Probability
* Allele
* Dominant
* Recessive
* Co-dominant
* Genotype
* Phenotype
* Type A blood
* Type B blood
* Type AB blood
* Type O blood
* Heterozygous
* Homozygous
* Carrier
* Law of segregation
* Law of independent assortment

**Blood Typing**

Blood groups are based on presence/absence of antigens on the surface of a red blood cell. The ABO blood group is based on the presence of one (or 2) of 3 antigens (A, B, or no antigen (O)) on the surface of red blood cells.

There are 3 different alleles (a case of **multiple alleles** for a trait) for the gene that determines which blood type an individual will have: the A allele (IA), the B allele (IB), and the O allele (i). Both the A allele and the B allele **dominate** over the O allele and the A and B alleles **co-dominate**.

Each person has 2 alleles for blood type (one inherited from each parent). Given the possible parental alleles in the table below, fill in the possible offspring alleles for blood type and then answer the questions below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parent Allele** | **IA** | **IB** | **i** |
| **IA** | **IA IA** |  |  |
| **IB** |  | **IB IB** |  |
| **i** |  |  | **ii** |

**Questions to discuss**

1. What percentage of the outcomes produces type A Blood?
2. What percentage of the outcomes produces type AB blood?
3. What percentage of the outcomes produces type B blood?
4. What percentage of the outcomes produces type O blood?

**Blood typing Problem 1**:

When producing offspring, each biological parent passes on ONE allele for blood type to their offspring. In a situation where one parent (the mother) has type A blood and the other parent (the father) has type B blood, how is it possible for them to have a child with type O blood? In other words show, using a Punnett square, what alleles each parent must have in order to have a child with type O blood.

 Offspring alleles shown to left

Given the above Punnett Square, answer the following questions.

1. What is the probability that these 2 parents would have a child with type O blood?
2. What is the probability that these 2 parents would have a child with type AB blood?
3. What is the probability that these 2 parents would have a child with type A blood?
4. What is the probability that these 2 parents would have a child with type B blood?

**Blood typing Problem 2**:

A mother with type B blood has 2 offspring. The first offspring has type A blood and the second offspring has type O blood.

1. What is the blood type of the father of these children?

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| Parent Alleles |  |  |
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**Sickle Cell Anemia**

Sickle cell anemia is a **homozygous recessive (ss)** disease characterized by abnormally shaped red blood cells that are fragile and susceptible to breaking because they are less flexible than normal red blood cells. The sickle shape is a result of a mutation in the  globin gene for hemoglobin, which causes the hemoglobin to aggregate in low oxygen conditions. Because this form of anemia is homozygous recessive (ss), a heterozygote (Ss) can be a **carrier** of the trait, but not show signs of the disease.

**Questions**:

1. If 2 parents are carriers of the trait for sickle cell, what is the probability that they will have offspring that are carriers?
2. If 2 parents are carriers of the trait for sickle cell, what is the probability that they will have offspring that are non-carriers but not affected by sickle cell?
3. If 2 parents are carriers of the trait for sickle cell, what is the probability that they will have offspring that have sickle cell anemia?

**Double-Factor Crosses**

The alleles for the ABO blood group and sickle cell are found on different chromosomes (chromosome 9 for the ABO alleles and chromosome 11 for the B globin allele for hemoglobin).

If you have 2 parents who are heterozygous for type A blood (IAi) and the sickle cell trait (Ss),

1. What types of offspring can these parents produce?
2. What is the probability that they will produce each type of offspring?

Note: keep in mind the possible gametes that can be formed and insert those combinations into the top row and left column for possible parental alleles. You need to keep in mind the law of segregation and law of independent assortment here!

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| Parent Alleles |  |  |  |  |
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**Di-hybrid cross** (modified from <http://www.ksu.edu/biology/pob/genetics/dihy.htm>)

Phenylthiocarbamide (PTC) is a chemical that is perceived as bitter by many Americans. The ability to taste the bitter is a dominant trait (T) and the inability a recessive trait (t). Albinism is also a single locus trait with normal pigment being dominant (A) and the lack of pigment being recessive (a). A normally pigmented (heterozygous) woman who tastes PTC (heterozygous) marries a normally pigmented man (homozygous) who is also a taster of PTC (heterozygous).

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| --- | --- | --- | --- | --- |
| Parent Alleles |  |  |  |  |
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**Questions**:

1. What are the genotypes of the possible offspring and the probability of having an offspring with each genotype?
2. What is the probability that any of the offspring will be non-tasters?
3. What is the probability that any of the offspring will be albino?

**Incomplete Dominance** (modified from http://www.ksu.edu/biology/pob/genetics/incom.htm)

A naturalist visiting an island in the middle of a large lake observes a species of small bird with three distinct types of beaks. Those with short, crushing beaks (BB) consume hard-shelled nuts, those with long, delicate beaks (bb) pick the seeds from pine cones, and those with intermediate beaks (Bb), consume both types of seeds though they are not as good at either. Assume that this difference in beak morphology is the result of incomplete dominance in a single locus gene.

1. If a bird with short crushing beaks mated with a bird with intermediate beaks, what is the probability of having an offspring that would be well-suited to consume hard-shelled nuts?
2. If a bird with short crushing beaks mated with a bird with a long delicate beak, what is the probability of having an offspring that would be well-suited to consume hard-shelled nuts?
3. If a bird with an intermediate beak mated with a bird with a long delicate beak, what is the probability of having an offspring that would be well-suited to consume hard-shelled nuts?